

# Dams on Nile River, High dam in Egypt, Sudan's Dams, Grand Ethiopian "Renaissance Dam" and its effect on the water budget of Egypt

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**Abstract:** in this paper we will talk about Dams on Nile River, but because Nile considered as a tallest river in the world we will focus only at dams in the biggest countries, High dam and Aswan old dam in Egypt, Sudan's Dams, Grand Ethiopian "Renaissance Dam" and its effect on the water budget of Egypt

## The Nile River

The Nile is a major north-flowing river in northeastern Africa, and is commonly regarded as the longest river in the world, though some sources cite the Amazon River as the longest. The Nile, which is 6,853 km (4,258 miles) long, is an "international" river as its drainage basin covers eleven countries, namely, (( Tanzania, Uganda, Rwanda, Burundi, the Democratic Republic of the Congo, Kenya, Ethiopia, Eritrea, South Sudan, Republic of the Sudan and Egypt)). In particular, the Nile is the primary water source of Egypt and Sudan. <sup>(1)</sup>

The Nile has two major tributaries, the White Nile and Blue Nile. The White Nile is considered to be the headwaters and primary stream of the Nile itself. The Blue Nile, however, is the source of most of the water and silt. The White Nile is longer and rises in the Great Lakes region of central Africa, with the most distant source still undetermined but located in either Rwanda or



Burundi. It flows north through Tanzania, Lake Victoria, Uganda and South Sudan. The Blue Nile begins at Lake Tana in Ethiopia and flows into Sudan from the southeast. The two rivers meet just north of the Sudanese capital of Khartoum.

The northern section of the river flows north almost entirely through the Sudanese desert to Egypt, then ends in a large delta and flows into the Mediterranean Sea. Egyptian civilization and Sudanese kingdoms have depended on the river since ancient times. Most of the population and cities of Egypt lie along those parts of the Nile valley north of Aswan, and nearly all the cultural and historical sites of Ancient Egypt are found along riverbanks

The drainage basin of the Nile covers 3,254,555 square kilometers (1,256,591 sq mi), about 10% of the area of Africa.<sup>[2]</sup> The Nile basin is complex, and because of this, the discharge at any given point along the main stem depends on many factors including weather, diversions, evaporation and evapotranspiration, and groundwater flow.

Sources: The source of the Nile is sometimes considered to be Lake Victoria, but the lake has feeder rivers of considerable size. The Kagera River, which flows into Lake Victoria near the Tanzanian town of Bukoba, is the longest feeder, although sources do not agree on which is the longest tributary of the Kagera and hence the most distant source of the Nile itself.<sup>[3]</sup> It is either the Ruvyironza, which emerges in Bururi Province, Burundi,<sup>[4]</sup> or the Nyabarongo, which flows from Nyungwe Forest in Rwanda.<sup>[5]</sup> The two feeder rivers meet near Rusumo Falls on the Rwanda-Tanzania border.

The source of the Nile from an underwater spring at the neck of Lake Victoria, Jinja

## **Tributaries**

### **Atbara River**

Below the confluence with the Blue Nile the only major tributary is the Atbara River, roughly halfway to the sea, which originates in Ethiopia north of Lake Tana, and is around 800 kilometers (500 mi) long. The Atbara flows only while there is rain in Ethiopia and dries very rapidly. During the dry period of January to June, it typically dries up. It joins the Nile approximately 300 kilometers (200 mi) north of Khartoum.

### **Blue Nile**

The Blue Nile springs from Lake Tana in the Ethiopian Highlands. The Blue Nile flows about 1,400 kilometres to Khartoum, where the Blue Nile and White Nile join to form the Nile.<sup>[6]</sup> Ninety percent of the water and ninety-six percent of the transported sediment carried by the Nile<sup>[7]</sup> originates in Ethiopia, with fifty-nine percent of the water from the Blue Nile (the rest being from the Tekezé, Atbarah, Sobat, and small tributaries). The erosion and transportation of silt only occurs during the Ethiopian rainy season in the summer, however, when rainfall is especially high on the Ethiopian Plateau; the rest of the year, the great rivers draining Ethiopia into the Nile (Sobat, Blue Nile, Tekezé, and Atbarah) have a weaker flow. In harsh and arid seasons and droughts the blue Nile dries out completely.<sup>[8]</sup>

The flow of the Blue Nile varies considerably over its yearly cycle and is the main contribution to the large natural variation of the Nile flow. During the dry season the natural discharge of the Blue Nile can be as low as 113 m<sup>3</sup>/s (4,000 cu ft/s), although upstream dams regulate the flow of the river. During the wet season the peak flow of the Blue Nile often exceeds 5,663 m<sup>3</sup>/s (200,000 cu ft/s) in late August (a difference of a factor of 50).

Before the placement of dams on the river the yearly discharge varied by a factor of 15 at Aswan. Peak flows of over 8,212 m<sup>3</sup>/s (290,000 cu ft/s) occurred during late August and early September, and minimum flows of about 552 m<sup>3</sup>/s (19,500 cu ft/s) occurred during late April and early May.

### **Bahr el Ghazal and Sobat River**

The Bahr al Ghazal and the Sobat River are the two most important tributaries of the White Nile in terms of discharge.

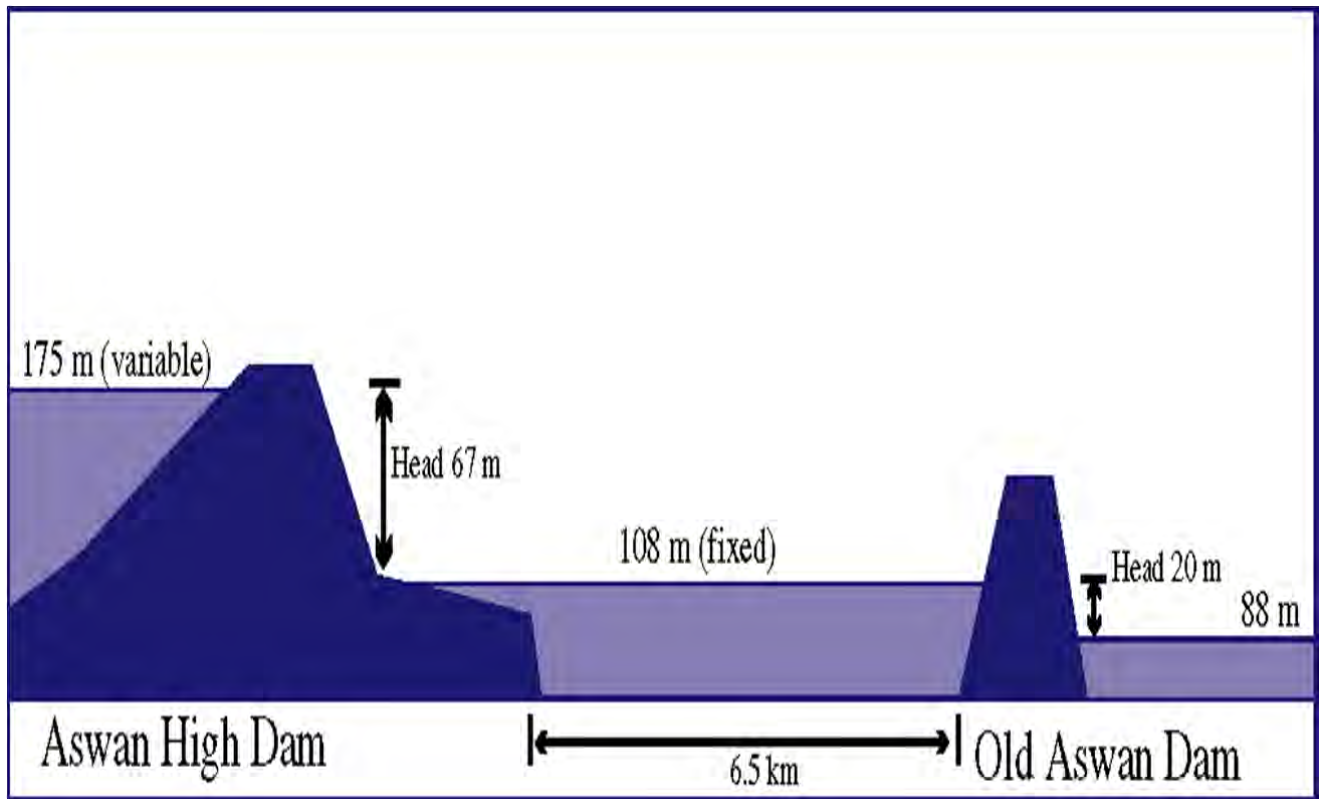
The Bahr al Ghazal's drainage basin is the largest of any of the Nile's sub-basins, measuring 520,000 square kilometers (200,000 sq mi) in size, but it contributes a relatively small amount of water, about 2 m<sup>3</sup>/s (71 cu ft/s) annually, due to tremendous volumes of water being lost in the Sudd wetlands.

The Sobat River, which joins the Nile a short distance below Lake No, drains about half as much land, 225,000 km<sup>2</sup> (86,900 sq mi), but contributes 412 cubic meters per second (14,500 cu ft/s) annually to the Nile.[9] When in flood the Sobat carries a large amount of sediment, adding greatly to the White Nile's color.[10]

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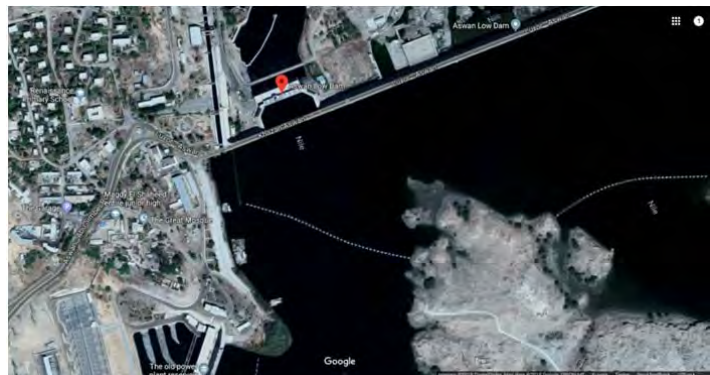
## Aswan Dams in Egypt



The diagram shows the Low and the High Dams.

There are two Dams in Egypt Old Aswan Dam and Aswan High Dam

### 1- The Aswan Low Dam or Old Aswan Dam



The Aswan Low Dam or Old Aswan Dam is a gravity masonry buttress dam on the Nile River in Aswan, Egypt. The dam was built at the former first cataract of the Nile, and is located about 1000 km up-river and 690 km (direct distance) south-southeast of Cairo. When initially constructed between 1899 and 1902, nothing of its scale had ever been attempted; on completion, it was the largest masonry dam in the world. The dam was designed to provide storage of annual floodwater and augment dry season flows to support greater irrigation development <sup>[1]</sup> and population growth in the lower Nile. The dam, originally limited in height by conservation concerns, worked as designed, but provided inadequate storage capacity for planned development and was raised twice, between 1907 and 1912 and again in 1929–1933. These heightenings still did not meet irrigation demands and in 1946 it was nearly over-topped in an effort to maximize pool elevation. This led to the investigation and construction of the Aswan High Dam 6.5 kilometres (4 mi) upstream. <sup>[2]</sup>



### **Background:**

The earliest recorded attempt to build a dam near Aswan was in the 11th century, when the Arab polymath and engineer Ibn al-Haytham (known as Alhazen in the West) was summoned to Egypt by the Fatimid Caliph, Al-Hakim bi-Amr Allah, to regulate the flooding of the Nile, a task requiring an early attempt at an Aswan Dam. <sup>[3]</sup> After his field work convinced him of the impracticality of this scheme, <sup>[4]</sup> and fearing the Caliph's anger, he feigned madness. He was kept under house arrest from 1011 until al-Hakim's death in 1021, during which time he wrote his influential Book of Optics.

### **Construction:**

Following their 1882 invasion and occupation of Egypt, the British began construction of the first dam across the Nile in 1898. Construction lasted until 1902, and it was opened on 10 December 1902, by HRH the Duke of Connaught and Strathearn. The project was designed by Sir William Willcocks and involved several eminent engineers of the time, including Sir Benjamin Baker and Sir John Aird, whose firm, John Aird & Co., was the main contractor. <sup>[5][6]</sup> Capital and financing were furnished by Ernest Cassel. <sup>[7]</sup>

The Old Aswan Dam was designed as a gravity-buttress dam; the buttress sections accommodate numerous gates, which were opened yearly to pass the flood and its nutrient-rich sediments, but without retaining any yearly storage. The dam was constructed of rubble masonry and faced with red ashlar granite. When constructed, the Old Aswan Dam was the largest masonry dam in the world.[8] The design also included a navigation lock of similar construction on the western bank, which allowed shipping to pass upstream as far as the second cataract, whereas a portage overland was previously required. At the time of its construction, nothing of such scale had ever been attempted.<sup>[9]</sup>

### **Heightening:**

Despite initial limitations imposed on its height, due to concern for the Philae Temple, the initial construction was soon found to be inadequate for development needs, and the height of the dam was raised in two phases, 5 metres (16 ft) between 1907–1912 and 9 metres (30 ft) between 1929–1933, and generation of electricity was added. The first phase was supervised by Sir Benjamin Baker.<sup>[10]</sup>

With its final raising, the dam is 1,950 metres (6,400 ft) in length, with a crest level 36 metres (118 ft) above the original riverbed;[8] the dam provides the main route for traffic between the city and the airport. With the construction of the High Dam upstream, the Old Dam's ability to pass the flood's sediments was lost, as was the serviceability provided by the locks. The previous Old Dam reservoir level was also lowered and now provides control of tail water for the High Dam.

### **Power plants:**

The Aswan Low Dam supports two hydroelectric power plants, Aswan I (1960) and Aswan II (1985–1986). Aswan I contains 7 X 40 megawatts (54,000 hp) generators with Kaplan turbines for a combined capacity of 280 megawatts (380,000 hp) and is located west of the dam. Aswan II contains 4 x 67.5 megawatts (90,500 hp) generators for an installed capacity of 270 megawatts (360,000 hp) and is located at the toe of the dam.<sup>[11]</sup>

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## 2- Aswan High Dam

The Aswan Dam, or more specifically since the 1960s, the Aswan High Dam, is an embankment dam built across the Nile in Aswan, Egypt, between 1960 and 1970. Its significance largely eclipsed the previous Aswan Low Dam initially completed in 1902 downstream. Based on the success of the Low Dam, then at its maximum utilization, construction of the High Dam became a key objective of the government following the Egyptian Revolution of 1952; with its ability to control flooding better, provide increased water storage for irrigation and generate hydroelectricity the dam was seen as pivotal to Egypt's planned industrialization. Like the earlier implementation, the High Dam has had a significant effect on the economy and culture of Egypt.



Before the High Dam was built, even with the old dam in place, the annual flooding of the Nile during late summer had continued to pass largely unimpeded down the valley from its East African drainage basin. These floods brought high water with natural nutrients and minerals that annually enriched the fertile soil along its floodplain and delta; this predictability had made the Nile valley ideal for farming since ancient times. However, this natural flooding varied, since high-water years could destroy the whole crop, while low-water years could create widespread drought and associated famine. Both these events had continued to occur periodically. As Egypt's population grew and technology increased, both a desire and the ability developed to completely control the flooding, and thus both protect and support farmland and its economically important cotton crop. With the greatly increased reservoir storage provided by the High Aswan Dam, the floods could be controlled and the water could be stored for later release over multiple years.

The Aswan Dam was designed by the Moscow-based Hydroproject Institute.<sup>[2]</sup>

### **Construction history:-**

The earliest recorded attempt to build a dam near Aswan was in the 11th century, when the Arab polymath and engineer Ibn al-Haytham (known as Alhazen in the West) was summoned to Egypt by the Fatimid Caliph, Al-Hakim bi-Amr Allah, to regulate the flooding of the Nile, a task requiring an early attempt at an Aswan Dam.<sup>[3]</sup> His field work convinced him of the impracticality of this scheme.<sup>[4]</sup>

### **Aswan High Dam prelude, 1954–1959:-**

1960: Start of construction on 9 January[5]

1964: First dam construction stage completed, reservoir started filling

1970: The High Dam, as-Sad al-'Aali, completed on 21 July[6]

1976: Reservoir reached capacity.

### **Specifications:-**

The Aswan High Dam is 3,830 metres (12,570 ft) long, 980 m (3,220 ft) wide at the base, 40 m (130 ft) wide at the crest and 111 m (364 ft) tall. It contains 43,000,000 cubic metres (56,000,000 cu yd) of material. At maximum, 11,000 cubic metres per second (390,000 cu ft/s) of water can pass through the dam. There are further emergency spillways for an extra 5,000 cubic metres per second (180,000 cu ft/s), and the Toshka Canal links the reservoir to the Toshka Depression. The reservoir, named Lake Nasser, is 550 km (340 mi) long and 35 km (22 mi) at its widest, with a surface area of 5,250 square kilometres (2,030 sq mi). It holds 132 cubic kilometres ( $1.73 \times 10^{11}$  cu yd) of water.

The dam was designed to be the highest level of water reserved in front of 138 meters, where the storage capacity of the lake at this level of 161 billion cubic meters, was established flood Toshka at the end of 1131 to protect the country from the dangers of high flooding, if the level of the high dam to 173 meters , Through the flood of Toshka.

### **Irrigation scheme**

Due to the absence of appreciable rainfall, Egypt's agriculture depends entirely on irrigation. With irrigation, two crops per year can be produced, except for sugar cane which has a growing period of almost one year.

The high dam at Aswan releases, on average, 55 cubic kilometres (45,000,000 acre·ft) water per year, of which some 46 cubic kilometres (37,000,000 acre·ft) are diverted into the irrigation canals.

In the Nile valley and delta, almost 33,600 square kilometres (13,000 sq mi) benefit from these waters producing on average 1.8 crops per year. The annual crop consumptive use of water is about 38 cubic kilometres (31,000,000 acre·ft). Hence, the overall irrigation efficiency is  $38/46 = 0.82$  or 82%. This is a relatively-high irrigation efficiency. The field irrigation efficiencies are much less, but the losses are reused downstream. This continuous reuse accounts for the high overall efficiency.

The following table shows that the equal distribution of irrigation water over the branch canals taking off from the one main irrigation canal, the Mansuriya Canal near Giza, leaves much to be desired:<sup>[7]</sup>

Branch canal    Water delivery in m<sup>3</sup>/feddan\*

Kafret Nasser    4,700



Beni Magdul	3,500
El Mansuria	3,300
El Hammami upstream	2,800
El Hammami downstream	1,800
El Shimi	1,200

\* Period 1 March to 31 July. 1 feddan is 0.42 ha or about 1 acre.

\* Data from the Egyptian Water Use Management Project (EWUP)<sup>[8]</sup>

Drainage through subsurface drains and drainage channels is essential to prevent a deterioration of crop yields from waterlogging and soil salinization caused by irrigation. By 2003, more than 20,000 square kilometres (7,700 sq mi) have been equipped with a subsurface drainage system and approximately 7.2 square kilometres (2.8 sq mi) of water is drained annually from areas with these systems. The total investment cost in agricultural drainage over 27 years from 1973 to 2002 was about \$3.1 billion covering the cost of design, construction, maintenance, research and training. During this period 11 large-scale projects were implemented with financial support from World Bank and other donors.<sup>[9]</sup>

### **Effects:-**

The High Dam has resulted in protection from floods and droughts, an increase in agricultural production and employment, electricity production, and improved navigation that also benefits tourism. Conversely, the dam flooded a large area, causing the relocation of over 100,000 people. Many archaeological sites were submerged while others were relocated. The dam is blamed for coastline erosion, soil salinity, and health problems.

The assessment of the costs and benefits of the dam remains controversial decades after its completion. According to one estimate, the annual economic benefit of the High Dam immediately after its completion was E£255 million, \$587 million using the exchange rate in 1970 of \$2.30 per E£1): £140 million from agricultural production, £100 million from hydroelectric generation, £10 million from flood protection, and £5 million from improved navigation. At the time of its construction, total cost, including unspecified "subsidiary projects" and the extension of electric power lines, amounted to £450 million. Not taking into account the negative environmental and social effects of the dam, its costs are thus estimated to have been recovered within only two years.<sup>[10]</sup> One observer notes: "The impacts of the Aswan High Dam (...) have been overwhelmingly positive. Although the Dam has contributed to some environmental problems, these have proved to be significantly less severe than was generally expected, or currently believed by many people."<sup>[11]</sup> Another observer disagreed and he recommended that the dam

should be torn down. Tearing it down would cost only a fraction of the funds required for "continually combating the dam's consequential damage" and 500,000 hectares of fertile land could be reclaimed from the layers of mud on the bed of the drained reservoir.<sup>[12]</sup>

Periodic floods and droughts have affected Egypt since ancient times. The dam mitigated the effects of floods, such as those in 1964, 1973, and 1988. Navigation along the river has been improved, both upstream and downstream of the dam. Sailing along the Nile is a favorite tourism activity, which is mainly done during the winter when the natural flow of the Nile would have been too low to allow navigation of cruise ships.[clarification needed] A new fishing industry has been created around Lake Nasser, though it is struggling due to its distance from any significant markets. The annual production was about 35 000 tons in the mid-1990s. Factories for the fishing industry and packaging have been set up near the Lake.[13]

#### Drought protection, agricultural production and employment

The Egyptian countryside benefited from the Aswan High Dam through improved irrigation as well as electrification, as shown here south of Luxor.

The dams also protected Egypt from the droughts in 1972–73 and 1983–87 that devastated East and West Africa. The High Dam allowed Egypt to reclaim about 2.0 million feddan (840,000 hectares) in the Nile Delta and along the Nile Valley, increasing the country's irrigated area by a third. The increase was brought about both by irrigating what used to be desert and by bringing under cultivation of 385,000 ha that were previously used as flood retention basins.[14] About half a million families were settled on these new lands. In particular the area under rice and sugar cane cultivation increased. In addition, about 1 million feddan (420,000 hectares), mostly in Upper Egypt, were converted from flood irrigation with only one crop per year to perennial irrigation allowing two or more crops per year. On other previously irrigated land, yields increased because water could be made available at critical low-flow periods. For example, wheat yields in Egypt tripled between 1952 and 1991 and better availability of water contributed to this increase. Most of the 32 km<sup>3</sup> of freshwater, or almost 40 percent of the average flow of the Nile that were previously lost to the sea every year could be put to beneficial use. While about 10 km<sup>3</sup> of the water saved is lost due to evaporation in Lake Nasser, the amount of water available for irrigation still increased by 22 km<sup>3</sup>.<sup>[13]</sup> Other estimates put evaporation from Lake Nasser at between 10 and 16 cubic km per year.<sup>[15]</sup>

#### **Electricity production:**

The dam powers twelve generators each rated at 175 megawatts (235,000 hp), with a total of 2.1 gigawatts (2,800,000 hp). Power generation began in 1967. When the High Dam first reached peak output it produced around half of Egypt's production of electric power (about 15 percent by 1998), and it gave most Egyptian villages the use of electricity for the first time. The High Dam has also improved the efficiency and the extension of the Old Aswan Hydropower stations by regulating upstream flows.<sup>[13]</sup>

#### **Resettlement**

Lake Nasser flooded much of lower Nubia and 100,000 to 120,000 people were resettled in Sudan and Egypt.<sup>[16]</sup>

View of New Wadi Halfa, a settlement created on the shore of Lake Nasser to house part of the resettled population from the Old Wadi Halfa town.

In Sudan, 50,000 to 70,000 Sudanese Nubians were moved from the old town of Wadi Halfa and its surrounding villages. Some were moved to a newly created settlement on the shore of Lake Nasser called New Wadi Halfa, and some were resettled approximately 700 kilometres south to the semi-arid Butana plain near the town of Khashm el-Girba up the Atbara River. The climate there had a regular rainy season as opposed to their previous desert habitat in which virtually no rain fell. The government developed an irrigation project, called the New Halfa Agricultural Development Scheme to grow cotton, grains, sugar cane and other crops. The Nubians were resettled in twenty five planned villages that included schools, medical facilities, and other services, including piped water and some electrification.

In Egypt, the majority of the 50,000 Nubians were moved three to ten kilometers from the Nile near Kom Ombo, 45 kilometers downstream from Aswan in what was called "New Nubia". Housing and facilities were built for 47 village units whose relationship to each other approximated that in Old Nubia. Irrigated land was provided to grow mainly sugar cane.<sup>[17][18]</sup>

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## Dams in Sudan

The following are out of 8 total

6 Dams and 2 Power Stations

### a) Dams

- 1- Jebel Aulia Dam
- 2- Khashm el-Girba Dam
- 3- Merowe Dam
- 4- Roseires Dam
- 5- Sennar Dam
- 6- Upper Atbara and Setit Dam Complex

### b) Power Stations

- 1- Shereyk Power Station
- 2- Kajbar Power Station

## Merowe Dam

The Merowe Dam, also known as Merowe High Dam, Merowe Multi-Purpose Hydro Project or Hamdab Dam, is a large dam near Merowe Town in northern Sudan, about 350 kilometres (220 mi) north of the capital Khartoum. Its dimensions make it the largest contemporary hydropower project in Africa. It is situated on the river Nile, close to and inundating the 4th Cataract where the river divides into multiple smaller branches with large islands in between. Merowe is a city about 40 kilometres (25 mi) downstream from the construction site at Hamdab. The main purpose for building the dam was the generation of electricity.[2]

### - Technical details

The dam has a length of about 9 kilometres (5.6 mi) and a crest height of up to 67 metres (220 ft). It consists of concrete-faced rockfill dams on each river bank (the right bank dam is the largest part of the project, 4.3 km long and 53m high; the left bank is 1590 metres long and 50 metres high), an 883-metre (2,897 ft)-long 67-metre (220 ft)-high earth-core rockfill dam (the 'main dam') in the left river channel, and a live water section in the right river channel (sluices, spillway and a 300-metre power intake dam with turbine housings).[3] It contains a reservoir of 12.5 cubic kilometres (10,100,000 acre-ft), or about 20% of the Nile's annual flow; the intended reservoir level is 300 metres above sea level, with the Nile level downstream of the dam being about 265 metres. The reservoir lake is planned to extend 174 kilometres (108 mi) upstream.



## - Powerhouse

The powerhouse is equipped with ten 125 megawatts (168,000 hp) Francis turbines, each one designed for a nominal discharge rate of 300 cubic metres per second, and each one driving a 150 MVA, 15 kV synchronous generator. The planners expect an annual electricity yield of 5.5 terawatt-hours (20 PJ), corresponding to an average load of 625 megawatts (838,000 hp), or 50% of the rated load. To utilize the extra generation capacity, the Sudanese power grid will be upgraded and extended as part of the project, with about 500 kilometres (310 mi) of new 500 kV aerial transmission line across the Bayudah Desert to Atbara, continuing to Omdurman/Khartoum, as well as about 1,000 kilometres (620 mi) of 220 kV lines eastwards to Port Sudan and westwards along the Nile, connecting to Merowe, Dabba and Dongola.



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# Grand Ethiopian “Renaissance Dam”

The Grand Ethiopian Renaissance Dam, formerly known as the Millennium Dam and sometimes referred to as Hidase Dam, is a gravity dam on the Blue Nile River in Ethiopia that has been under construction since 2011. It is in the Benishangul-Gumuz Region of Ethiopia, about 15 km (9 mi) east of the border with Sudan.[3] At 6,450 MW, the dam will be the largest hydroelectric power plant in Africa when completed, as well as the 7th largest in the world.[4][5][6] As of August 2017, the work stood at 60% completion.[7] Once completed, the reservoir will take from 5 to 15 years to fill with water.[8]



## Background

The eventual site for the Grand Ethiopian Renaissance Dam was identified by the United States Bureau of Reclamation during a Blue Nile survey conducted between 1956 and 1964. The Ethiopian Government surveyed the site in October 2009 and August 2010. In November 2010, a design for the dam was submitted.[9] On 31 March 2011, a day after the project was made public, a US\$4.8 billion contract was awarded without competitive bidding to Salini Costruttori and the dam's foundation stone was laid on 2 April 2011 by then Prime Minister Meles Zenawi.[10] A rock crushing plant has been constructed along with a small air strip for fast transportation.[11] The first two generators are expected to become operational after 44 months of construction.[12] Egypt, which lies downstream, opposes the dam which it believes will reduce the amount of water that it gets from the Nile.[13] Zenawi argued, based on an unnamed study, that the dam would not reduce water availability downstream and would also regulate water for irrigation.[12] In May 2011, it was announced that Ethiopia would share blueprints for the dam with Egypt so the downstream impact could be examined.[14]



The dam was originally called "Project X", and after its contract was announced it was called the Millennium Dam.[15] On 15 April 2011, the Council of Ministers renamed it Grand Ethiopian Renaissance Dam.[16] Ethiopia has a potential for around 45,000 MW of hydropower.[17] The dam is being funded by government bonds and private donations. It was slated for completion in July 2017.[9]

The potential impacts of the dam have been the source of severe regional controversy. The Government of Egypt, a country which relies heavily on the waters of the Nile, has demanded that Ethiopia cease construction on the dam as a preconditions to negotiations, sought regional support for its position, and some political leaders have discussed methods to sabotage it.[18] Egypt has planned a diplomatic initiative to undermine support for the dam in the region as well as in other countries supporting the project such as China and Italy.[19] However, other nations in the Nile Basin Initiative have expressed

support for the dam, including Sudan, the only other nation downstream of the Blue Nile, which has accused Egypt of inflaming the situation.[20] Ethiopia denies that the dam will have a negative impact on downstream water flows and contends that the dam will in fact increase water flows to Egypt by reducing evaporation on Lake Nasser.[21] It has accused Egypt of being unreasonable; Egypt is demanding to increase its share of the Nile's water flow from 66% to 90%.[21]



## Design:

The design changed several times between 2011–2017. This affected both the electrical parameters and the storage parameters.

Originally, in 2011, the hydropower plant was to receive 15 generating units with 350 MW nameplate capacity each, resulting in a total installed capacity of 5,250 MW with an expected power generation of 15,128 GWh per annum.[23] However, due to the upgrading made on the power plant, its generation capacity was uplifted to 6,000 MW from 5,250 MW, with a power generation of 15,692 GWh per annum through 16 generating units with 375 MW nameplate capacity each. In 2017, the design has again been changed to add another 450 MW, with a power generation of 16,153 GWh per annum.[2][24] That was achieved by upgrading 14 of the 16 generating units from 375 MW to 400 MW without changing the nameplate capacity.[25]

Not only the electrical power parameters were to change over time, but also the storage parameters. Originally, in 2011, the dam was considered to be 145 m (476 ft) tall with a volume of 10.1 million m<sup>3</sup>. The reservoir was considered to have a volume of 66 km<sup>3</sup> (54,000,000 acre-ft) and a surface area of 1,680 km<sup>2</sup> (650 sq mi) at full supply level. The rock-filled saddle dam besides the main dam was considered to have a height of 45 m (148 ft) meters and a length of 4,800 m (15,700 ft) and a volume of 15 million m<sup>3</sup>.<sup>[9][26]</sup>

In 2013, an Independent Panel of Experts (IPoE) assessed the dam and its technological parameters. At that time, the reservoir sizes were changed already. The size of the reservoir at full supply level went up to 1,874 km<sup>2</sup> (724 sq mi) (plus 194 km<sup>2</sup>). The storage volume at full supply level had increased to 74 km<sup>3</sup> (60,000,000 acre-ft) (plus 7 km<sup>3</sup>).<sup>[27]</sup> These numbers did not change anymore after 2013.

After the IPoE made its recommendations, in 2013, the dam parameters were changed to account for higher flow volumes in case of extreme floods: a main dam height of 155 m (509 ft) (plus 10 meters) with a length of 1,780 m (5,840 ft) (no change) and a dam volume of 10.2 million m<sup>3</sup> (plus 0.1 million m<sup>3</sup>). The outlet parameters did not change, only the crest of the main dam was raised. The rock saddle dam went up to a height of 50 m (160 ft) (plus 5 meters) with a length of 5,200 m (17,100 ft) (plus 400 meters). The volume of the rock saddle dam increased to 16.5 million m<sup>3</sup> (plus 1.5 million m<sup>3</sup>).<sup>[27][28]</sup>

The design parameters as of August 2017 are as follows, given the changes as outlined above

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## **The environmental impact of the giant Nile dams**

The downstream countries maintain a fixed share of water in front of the High Dam (84 billion cubic meters), 85% of which comes from the Ethiopian plateau and 15% from the tropical plateau and southern Sudan.

And so the impact of the Ethiopian Plateau, Sudan and Southern Sudan projects is 90% on Egypt. The impact of the tropical plateau projects is only 10% on the share of Egypt, Sudan and Southern Sudan.

The transformation of the riverbed to facilitate the construction of the dam is governed by technical, engineering and geographic considerations, a temporary process that does not affect the flow of the river and then returns to its natural course, while the negative impact of the trans boundary water (Bypass) The dam will be filled up, and then the amount of water shortage in other countries will depend on the operational policy of the dam to produce electricity and meet the needs of agriculture and other uses, taking into consideration the share of the downstream countries of the water. And the tributaries according to the results of environmental geography to hold water from one state to another, it is certain that the course of the river was destined to change, but in a limited range does not exceed a few kilometers, the river must find its natural way, in terms of difference in the slope and the strength of flow to reach the mouth Sea.

In terms of maximizing the benefit of minimizing the environmental impact of floods in their downstream, dams are likely to be built in the highlands, although their capital cost is based on the fundamentals and parameters of safety factors for dam collapse scenarios under all circumstances.

There is no dispute in the right of the Nile Basin countries in the economic and social return to build giant dams within their territories to reduce the water, food and development gap for the welfare of its people. Egypt built the High Dam (1971) and constructed it

Sudan Merowe Dam (2010) Ethiopia plans to build a series of dams, including Al Nahda Dam (2018) and Uganda Tanzania and others in the future.

International conventions and treaties regulate the use of water in a manner that preserves the survival of countries that are fully dependent on the river and the latest

(The 1959 Convention) between Egypt and Sudan, but with the emergence of logistics blocs to maximize the use of river water and advertising

Agreement Entebbe (2010), which cancels the Nile water distribution agreements during the colonial phase and reallocates them to serve

The demands of the upstream countries and the development of water resources, the crisis has evolved to the absence of the principle of compatibility, which differed by the basin countries.

And the absence of any project of the side effects and environmental, and that the need to build dams to control flow reducing the annual flood losses, exploiting its water supply and generating electricity

Economic development, this does not occur without the occurrence of many environmental impacts in the surrounding geographical area within the state of the dam and beyond borders,

including:

- Climate, environmental and ecological changes as a result of the occupation of the dam lake to large areas of land that is not free of the natural habitats of the wild and the rivers and their pastures.
- The sinking of agricultural land and housing and many of the historical monuments and reservoirs of natural resources that may exist in lake area.
- Forced displacement of indigenous peoples and their separation from their cultural and cultural heritage to areas far from their home social, cultural and residential development of their new lives in these areas, as well as the issue of compensation for damages their own property.
- Deprivation of agricultural land behind the dam from soil-fertilized flood materials, and the impact of compensation with pesticides chemicals on environmental health and food chain due to accumulation of pollutants in soil, crops and animals that feed the human.
- Increasing the process of water erosion around the rules of installations and river works.
- Increasing the accumulation of dead stock of silt in the dam lake leads in addition to loss of part of the storage capacity and its impact on the river life of fish and others, erodes beaches in the river delta due to the loss of natural balance in the sedimentation between the river and the sea.
- Increased loss of water in the lake, either because of high evaporation rate due to exposure to the vast surface of the sun and degrees high temperature. Or loss due to the high transpiration rates of the spread of some plants and their environmental adaptation to the new conditions.
- The possibility of the collapse of the dam as a result of military action or earthquakes or receiving a volume of flood water structural design pregnancy is superior when it occurs under sudden geological or climatic conditions.

### **- Dam of the Ethiopian Renaissance (Al-Nahda Dam) (2018)**

By building this controversial dam and suspicion, will control almost completely the revenue of the Blue Nile, about 40 Kilometers near the Sudanese-Ethiopian border, which has been completed more than 60% of its installations, one of three dams in Ethiopia is used for water storage and hydropower production, which is higher than the high dam (111 meters) 34 meters long and less in length by half (1800 meters) and also in the total storage capacity by about 44% with a storage capacity of 70 billion m<sup>3</sup>, but according to the design of this dam is one of the largest power generation projects in Africa (5250 MW) after its completion, equivalent to two and a half capacity of the high dam of electricity generation. )

Ethiopia is the only country in the basin that does not receive any water from outside its territory; underscoring the importance of dam construction it's economically viable. As well as the geographical nature of Ethiopia, which forbids it from retaining its water, as it resembles a "tower water "for the abundance of water from the highlands, which is estimated by its small rivers and lakes with more than

930 billion m<sup>3</sup> evaporates and leaks about 80% and the rest goes out to the north towards Sudan and Egypt and south to Kenya Somalia, and may have only 25 million m<sup>3</sup> left of this water.

Thus Ethiopia suffers an economic dilemma, from the lack of resources and natural resources, make them at the end of the list of the most read at the level of the countries of the world, and hopes to reap from behind this dam and others profits that move them to the ranks of middle-income countries , from the revenues of the export of electricity surplus to the basin countries and beyond, including - by the five-year plan (2025 - 2020), equivalent to 450 million dollars a year, which will increase to more than five billion dollars after the completion of the construction of other dams.

A scientific study (2011) confirmed that Ethiopia has a potential capacity of about 45 thousand megawatts, including 20 thousand megawatts of Blue Nile and its tributaries. And that it will lead the Horn of Africa and the Nile Basin by monopolizing the electrical power in the region and the exploitation of dams in irrigated agriculture. This requires the completion of the infrastructure to accommodate the large quantities of electricity generated by these dams, which will take a considerable period of time, in addition to finding a safe exit for the transport of this electricity, which is inevitable to be transported through the territory of Sudan or Egypt.

The effect of Al-Nahda Dam and the other Ethiopian dams on the Blue Nile and its tributaries is associated with the decline in the per capita water per capita in Egypt below the water poverty line (1000 m<sup>3</sup>) to 350 m<sup>3</sup> in 2050, , The limited water supply, the modest non-renewable groundwater reserves in Western Sahara, the high cost of desalination and the increasing food gap to about \$ 10 billion. This environmental impact is as follows:

- Loss of large areas of agricultural land estimated at two million acres.
- Low electricity of the High Dam, Aswan reservoir, Isna and Naga Hammadi basins for more than 500 megawatts per year.
- Drinking water purification plants are subject to suspension and many manufacturing industries are also shut down.
- Influence of gas-powered power plants based on cooling of Nile water.
- deterioration of water quality in canals and banks of lack of river wash.
- Reserving huge quantities of river sediments which, although relatively larger than the storage capacity of the High Dam Lake, but will increase the compost gap of agricultural land and its adverse effects on human health and the environment.
- Sea water intrusion into North Delta lands and deterioration of water quality in its lakes.

### **Merowe Sudanese Dam (2010)**

The Merowe dam is one of the largest hydropower projects after the dam

However, Ethiopia, with the completion of the Al Nahda dam project, will be ranked first in the production of electric power in Africa.

Some irrigation experts believe that the construction of the Merowe Dam takes from Egypt an average of nine billion cubic meters, which it receives from Sudan

Over its share of water, and the impact on the level of Lake High Dam with clouds of water reserves to meet Egypt's water requirements. But this dam is not only to seize the share of Sudan full of river water and this is the right, and will result

Has huge amounts of electricity and provides about 155 thousand acres for agricultural expansion projects.

The Merowe Dam was established by a special law, which is not subject to regulatory authority. The project was devoid of surveys and public consultation sessions, in addition to the weakness of the environmental impact assessment of the dam on the surrounding area prepared by the German consulting firm (2002) For Water Science and Technology (2006). In addition to the geographical location of the construction of the dam in the fourth waterfall of the geological and engineering aspects

In terms of heterogeneity of classes and the possibility of exposure to earthquakes, according to the study of the Russian team of the region (1984),

Many cracks have already appeared in the body of Al-Khorasani after the opening of the first phase.

There is no doubt that the Merowe dam has been protected from the lands behind it from strong and frequent floods and the reduction of its annual losses

The improvement of river navigation conditions, the formation of a large industrial lake for water storage and its impact on increasing the area of arable land by three times the current area,

Which is due to the Sudan to increase production capacity and employment opportunities and raise the standard of living and its impact on the national GDP. Not to mention the huge difference of gas pollution compared to thermal power stations causing global warming and the production of clean hydropower.

There are three population groups affected by the Merowe Dam Project, the Hammadab Group, Ameri in the Northern State and the Manaseer Group in the Wilayat of the Nile, about 52,000 indigenous people (11,000 families). All of their properties have been lost from the agricultural and residential lands flooded by the dam. The results came in a severe security crisis with the resettlement of those residents who want to stay around the lake in contradiction to forced displacement in the southern regions as far as the government's economic plan to exploit the land.

#### High Dam (1971)

After the establishment of the High Dam, the method of control of the river water changed from relying on the annual storage volume of the high flood water in the Aswan reservoir to continuous storage. The floodwater is not allowed to reach the sea, but it is stored in the giant dam lake (5250 km<sup>2</sup>) The strategic balance of water is drawn from a specific system according to the size of storage and requirements for agriculture, industry, electricity, navigation and others.

The construction of the High Dam was not affected by some of the environmental influences, including: the drowning of the Nubia country and its effects and the displacement of its inhabitants (1964)

The fourth Nubian migration The first three were after the construction of the Aswan reservoir and its aftermath (1902-1912-1933)

The dead stock of silt in the dam lake behind the deprivation of agricultural land from the causes of natural fertility and replace them with chemical fertilizers and their cumulative effect in soil, water, crops and field and human animals, as well as the erosion of beaches in the North Delta to stop the Nile to meet the natural rights of sediments that maintain the balance of the river

And the sea.

The bottom line:

The establishment of the right of upstream countries to exploit the Nile waters for economic and social development. And the determination of the right of the downstream countries to the historical quota of water, are two main rules that should be taken into account in any negotiations to agree on the outstanding points of the Entebbe Agreement or freeze the agreement for a period of time that allows for consensus among all parties. Taking into account the size of the cumulative environmental impact of all future projects of dams along the Nile Basin and not rely solely on the study of the environmental impact assessment of the construction of dams at the level of location and location in their countries without other countries with a crucial relationship with the river water.

The announcement of a project to benefit from the huge water losses in the Nile basin, which exceeds 150 billion m<sup>3</sup>, through an in-depth scientific study funded by donors, so that the establishment of major development hubs in the upstream countries. For States

Downstream The need for the Joint Technical Commission to study the negative impacts and consequences of the Ethiopian dams, and accelerate the revival of the Jonglei Integrated Canal Project, which will provide more than 5 billion cubic meters of water lost in swamps in the South

Sudan.

A project linking the Nile and the Congo rivers (1980) to the establishment of the Great Dung Dam, albeit a virtual project due to geographical constraints and its passage through the tropical forest area, is through the creation of a 600 km long canal that carries water to the Nile River Basin through southern Sudan, Naser Lake. The project will provide more than 100 billion cubic meters of water annually to Egypt, which is enough to grow half of Western Sahara, and produces more than 15,000 megawatts to cover half of the continent's electricity needs. This project needs to be studied in the long run in order to meet the growing needs as the population in both Egypt and Sudan grows.

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